2.0 OVERVIEW OF DREDGING OPERATIONS AND DREDGED MATERIAL MANAGEMENT ALTERNATIVES

2.1 General

This section of the report is intended to provide a brief introduction and overview of the dredging process, including types of dredges, transportation systems, and the placement or disposal practices commonly used in navigation dredging projects. References throughout this part provide more detailed discussion and explanation of different kinds of dredges, transport equipment, and disposal practices.

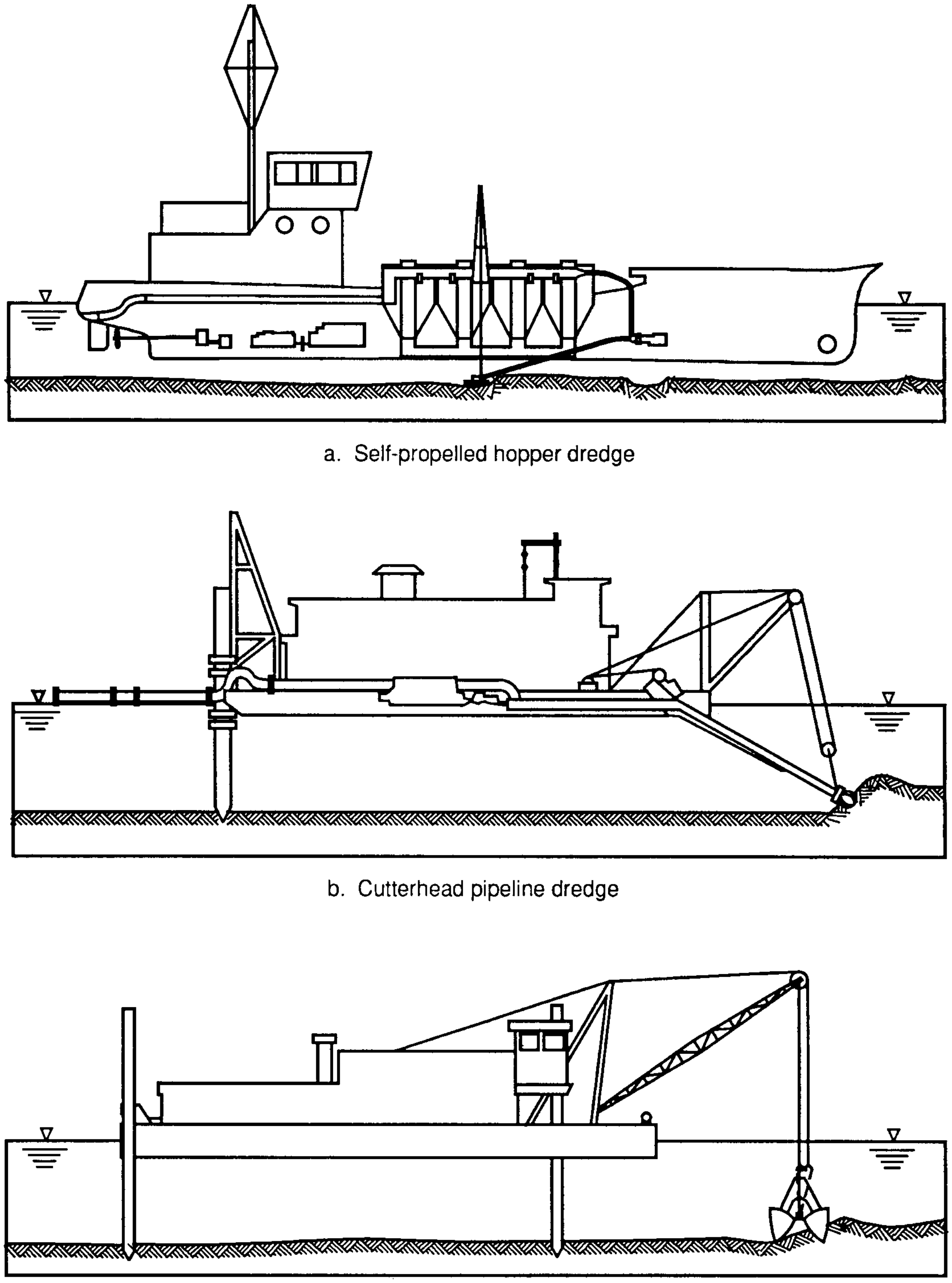
The removal or excavation, transport, and placement of dredged sediments are the primary components of the "dredging process." In design and implementation of any dredging project, each part of the dredging process must be closely coordinated to ensure a successful dredging operation.

The excavation process commonly referred to as "dredging" involves the removal of sediment in its natural (new-work construction) or recently deposited (maintenance) condition, either mechanically or hydraulically. After the sediment has been excavated, it is transported from the dredging site to the placement site or disposal area. This transport operation, in many cases, is accomplished by the dredge itself or by using additional equipment such as barges, scows, and pipelines with booster pumps.

Once the dredged material has been collected and transported, the final step in the dredging process is placement in either open-water, nearshore, or upland locations. The choice of management alternatives involves a variety of factors related to the dredging process including environmental acceptability, technical feasibility, and economic feasibility of the chosen alternative.

2.2 Dredging Process Equipment and Techniques

Compatibility must exist between the dredging equipment and techniques used for excavation and transport of the material and the management alternatives considered. The types of equipment and methods used by both the USACE and private industry vary considerably throughout the United States. The most commonly used dredges are illustrated in Figure 2-1. Dredging equipment and dredging operations resist precise categorization. As a result of specialization and tradition in the industry, numerous descriptive, often overlapping, terms categorizing dredges have developed. For example, dredges can be classified according to: the basic means of moving material (mechanical or hydraulic); the device used for excavating sediments (clamshell, cutterhead, dustpan, and plain suction); the type of pumping device used (centrifugal, pneumatic, or airlift);



a. Self-propelled hopper dredge

b. Cutterhead pipeline dredge

c. Clamshell dredge

Figure 2-1. Commonly Used Dredges

and others. However, for the purposes of this document, dredging is actually accomplished basically by only two mechanisms:

- Hydraulic dredging--Removal of loosely compacted materials by cutterheads, dustpans, hoppers, hydraulic pipeline plain suction, and sidecasters, usually for maintenance dredging projects.
- Mechanical dredging--Removal of loose or hard, compacted materials by clamshell, dipper, or ladder dredges, either for maintenance or new-work projects.

Hydraulic dredges remove and transport sediment in liquid slurry form. They are usually barge mounted and carry diesel or electric-powered centrifugal pumps with discharge pipes ranging from 6 to 48 in. in diameter. The pump produces a vacuum on its intake side, and atmospheric pressure forces water and sediments through the suction pipe. The slurry is transported by pipeline to a disposal area. Hopper dredges are included in the category of hydraulic dredges for this report even though the dredged material is simply pumped into the self-contained hopper on the dredge rather than through a pipeline. It is often advantageous to overflow hopper dredges to increase the load; however, this may not always be acceptable due to water quality concerns near the dredging site.

Mechanical dredges remove bottom sediment through the direct application of mechanical force to dislodge and excavate the material at almost in situ densities. Backhoe, bucket (such as clamshell, orange-peel, and dragline), bucket ladder, bucket wheel, and dipper dredges are types of mechanical dredges. Sediments excavated with a mechanical dredge are generally placed into a barge or scow for transportation to the disposal site.

Selection of dredging equipment and method used to perform the dredging will depend on the following factors:

- Physical characteristics of material to be dredged.
- Quantities of material to be dredged.
- Dredging depth.
- Distance to disposal area.
- Physical environment of the dredging and disposal areas.
- Contamination level of sediments.
- Method of disposal.
- Production required.
- Type of dredges available.
- Cost.

More detailed descriptions of dredging equipment and dredging processes are available in Engineer Manuals (USACE 1983 and USACE in preparation), Houston (1970), and Turner (1984).

2.3 Transportation of Dredged Material

Transportation methods generally used to move dredged material include the following: pipelines, barges or scows, and hopper dredges. Pipeline transport is the method most commonly associated with cutterhead, dustpan, and other hydraulic dredges. Dredged material may be directly transported by hydraulic dredges through pipelines for distances of up to several miles, depending on a number of conditions. Longer pipeline pumping distances are feasible with the addition of booster pumps, but the cost of transport greatly increases. Barges and scows, used in conjunction with mechanical dredges, have been one of the most widely used methods of transporting large quantities of dredged material over long distances. Hopper dredges are capable of transporting the material for long distances in a self-contained hopper. Hopper dredges normally discharge the material from the bottom of the vessel by opening the hopper doors; however, some hopper dredges are equipped to pump out the material from the hopper much like a hydraulic pipeline dredge.

2.4 Placement or Disposal Operations

Selection of proper dredging and transport equipment and techniques must be compatible with disposal site and management requirements. Three major alternatives are available:

- Open-water disposal.
- Confined disposal.
- Beneficial use.

Each of the major alternatives involves its own set of unique considerations, and selection of a management alternative should be made based on environmental, technical, and economic considerations.

2.4.1 Description of Open-Water Disposal

Open-water disposal is the placement of dredged material in rivers, lakes, estuaries, or oceans via pipeline or release from hopper dredges or barges. Such disposal may also involve appropriate management actions or controls such as capping. The potential for environmental impacts is affected by the physical behavior of the open-water discharge. Physical behavior is dependent on the type of dredging and disposal operation used, the nature of the material (physical characteristics), and the hydrodynamics of the disposal site.

Dredged material can be placed in open-water sites using direct pipeline discharge, direct mechanical placement, or release from hopper dredges or scows. A conceptual illustration of open-water disposal using the most common placement techniques is shown in Figure 2-2.

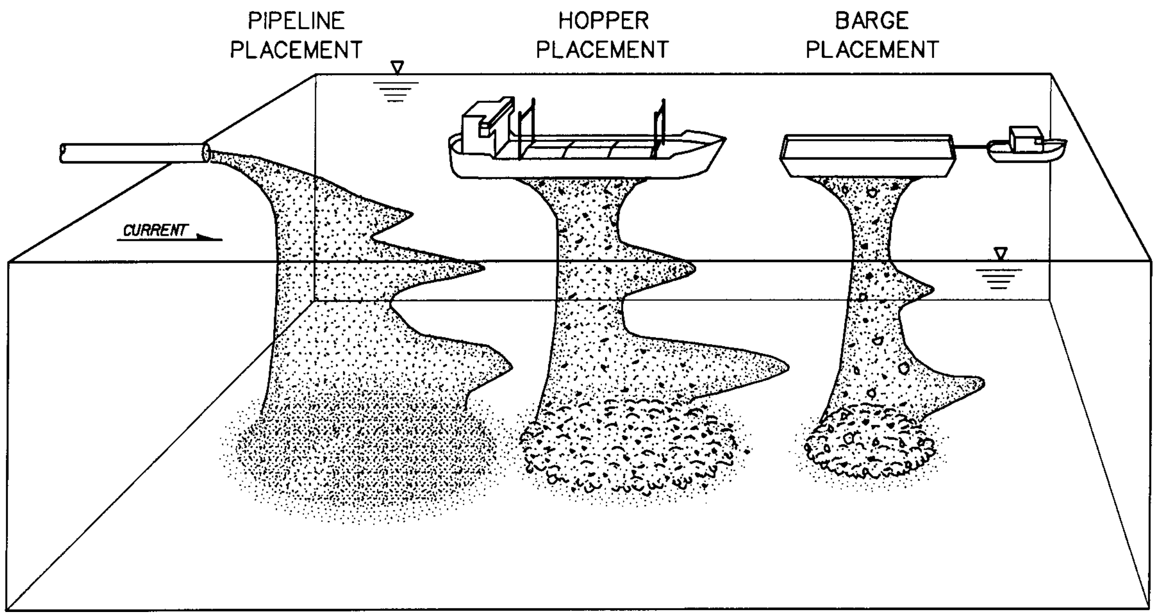


Figure 2-2. Open-water Placement Operations

Pipeline dredges are commonly used for open-water disposal adjacent to channels. Material from this dredging operation consists of a slurry with solids concentration ranging from a few grams per liter to several hundred grams per liter. Depending on material characteristics, the slurry may contain clay balls, gravel, or coarse sand material. This coarse material quickly settles to the bottom. The mixture of dredging site water and finer particles has a higher density than the disposal site water and therefore can descend to the bottom forming a fluid mud mound. Continuing the discharge may cause the mound to spread. Some fine material is "stripped" during descent and is evident as a turbidity plume. Characteristics of the plume are determined by: discharge rate, characteristics of the slurry (both water and solids), water depth, currents, meteorological conditions, salinity of receiving water, and discharge configuration.

The characteristics and operation of hopper dredges result in a mixture of water and solids stored in the hopper for transport to the disposal site. At the disposal site, hopper doors in the bottom of the ship's hull are opened, and the entire hopper contents are emptied in a matter of minutes; the dredge then returns to the dredging site to reload. This procedure produces a series of discrete discharges at intervals of perhaps one to several hours. Upon release from the hopper dredge at the disposal site, the dredged material falls through the water column as a well-defined jet of high-density fluid, which may contain blocks of solid material. Ambient water is entrained during descent. After it hits bottom, most of the dredged material comes to rest. Some material enters the horizontally spreading bottom surge formed by the impact and is carried away from the impact point until the turbulence of the surge is sufficiently reduced to permit its deposition.

Bucket or clamshell dredges remove the sediment being dredged at nearly its in situ density and place it on a barge or scow for transportation to the disposal area. Although several barges may be used so that the dredging is essentially continuous, disposal occurs as a series of discrete discharges. Barges are designed with bottom doors or with a split-hull, and the contents may be emptied within seconds, essentially as an instantaneous discharge. Often sediments dredged by clamshell remain in fairly large consolidated clumps and reach the bottom in this form. Whatever its form, the dredged material descends rapidly through the water column to the bottom, and only a small amount of the material remains suspended. Clamshell dredge operations may also be used for direct material placement adjacent to the area being dredged. In these instances, the material also falls directly to the bottom as consolidated clumps.

Dredge hoppers and scows are commonly filled past the point of overflow to increase the load. The gain in hopper or scow load and the characteristics of the associated overflow are dependent on the characteristics of the material being dredged and the equipment being used. There is little debate that the load can be increased by overflow if the material dredged is coarse grained or forms clay balls, as commonly occurs with new-work dredging. For fine-grained maintenance material, significant disagreement exists as to whether a load gain can be achieved by overflow. Environmental considerations of overflow may be related to aesthetics, potential effects of water-column turbidity, potential effects of deposition of solids, or potential effects of sediment-associated contaminants (Palermo and Randall 1990).

Open-water disposal sites can be either predominantly nondispersive or predominantly dispersive. At predominantly nondispersive sites, most of the material is intended to remain on the bottom following placement and may be placed to form mounds. At predominantly dispersive sites, material may be dispersed either during placement or eroded from the bottom over time and transported away from the disposal site by currents and/or wave action. However, both predominantly dispersive and predominantly nondispersive sites can be managed in a number of ways to achieve environmental objectives or reduce potential operational conflicts. Additional discussion of open-water disposal processes is found in Chapter 4.

2.4.2 Description of Confined Disposal

Confined disposal is placement of dredged material within diked nearshore or upland confined disposal facilities[5] (CDFs) via pipeline or other means. The term CDF is used in this document in its broadest sense. CDFs may be constructed as upland sites, nearshore sites with one or more sides in water (sometimes called intertidal sites), or as island containment areas as shown in Figure 2-3.

[5] The terms "confined disposal facility," "confined disposal area," "confined disposal site," "diked disposal site," and "containment area" all appear in the literature and refer to an engineered structure for containment of dredged material. The confinement dikes or structures in a CDF enclose the disposal area above any adjacent water surface, isolating the dredged material from adjacent waters during placement. In this document, confined disposal does not refer to subaqueous capping or contained aquatic disposal (see Chapter 4).

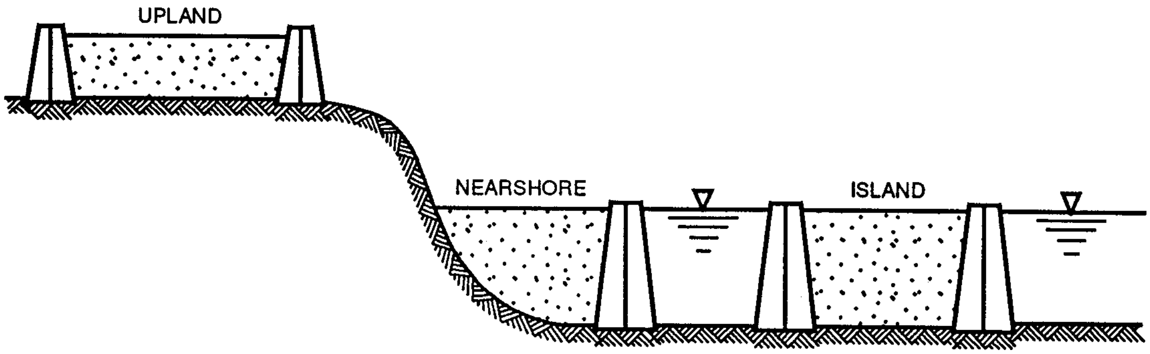


Figure 2-3. Upland, Nearshore, and Island CDFs

The two objectives inherent in design and operation of CDFs are to provide for adequate storage capacity for meeting dredging requirements and to maximize efficiency in retaining the solids. However, if contaminants are present, control of contaminant releases may also be an objective. Basic guidance for design, operation, and management of CDFs is found in Engineer Manuals (USACE 1983, 1987 and in preparation).

Hydraulic dredging adds several volumes of water for each volume of sediment removed, and this excess water is normally discharged as effluent from the CDF during the filling operation. The amount of water added depends on the design of the dredge, physical characteristics of the sediment, and operational factors such as pumping distance. When the dredged material is initially deposited in the CDF, it may occupy several times its original volume. The settling process is a function of time, but the sediment will eventually consolidate to its in situ volume or less if desiccation occurs. Adequate volume must be provided during the dredging operation to contain the total volume of sediment to be dredged, accounting for any volume changes during placement.

Some CDFs are filled by mechanically rehandling dredged material from barges filled by mechanical dredges. Material placed in the CDF in this manner is at or near its in situ water content. If such sites are constructed in water, the effluent volume may be limited to the water displaced by the dredged material, and the settling behavior of the material is not as important.

In most cases, CDFs must be used over a period of many years, storing material dredged periodically over the design life. Long-term storage capacity of these CDFs is therefore a major factor in design and management. Once water is drained from the CDF following active disposal operations, natural drying forces begin to dewater the dredged material, adding additional storage capacity. The gains in storage capacity are therefore influenced by consolidation and drying processes and the techniques used to manage the site both during and following active disposal operations. Additional discussion of confined disposal processes is found in Chapter 5.

2.4.3 Categories of Beneficial Use

Beneficial use includes a wide variety of options, which utilize the material for some productive purpose. Dredged material is a manageable, valuable soil resource, with beneficial uses of such importance that they should be incorporated into project plans and goals at the project's inception to the maximum extent possible.

Ten broad categories of beneficial uses have been identified, based on the functional use of the dredged material or site. They are:

- Habitat restoration/enhancement (wetland, upland, island, and aquatic sites including use by waterfowl and other birds).
- Beach nourishment.
- Aquaculture.
- Parks and recreation (commercial and noncommercial).
- Agriculture, forestry, and horticulture.
- Strip mine reclamation and landfill cover for solid waste management.
- Shoreline stabilization and erosion control (fills, artificial reefs, submerged berms, etc.).
- Construction and industrial use (including port development, airports, urban, and residential).
- Material transfer (fill, dikes, levees, parking lots, and roads).
- Multiple purpose.

Opportunities for beneficial use applications under each of these categories are discussed in Chapter 6. Detailed guidelines for various beneficial use applications are given in Engineer Manuals (USACE 1983, 1986 and in preparation). Additional information and case studies on beneficial use are available at the following website, which is a collaborative effort between USACE and USEPA: http://www.wes.army.mil/el/dots/budm/budm.html